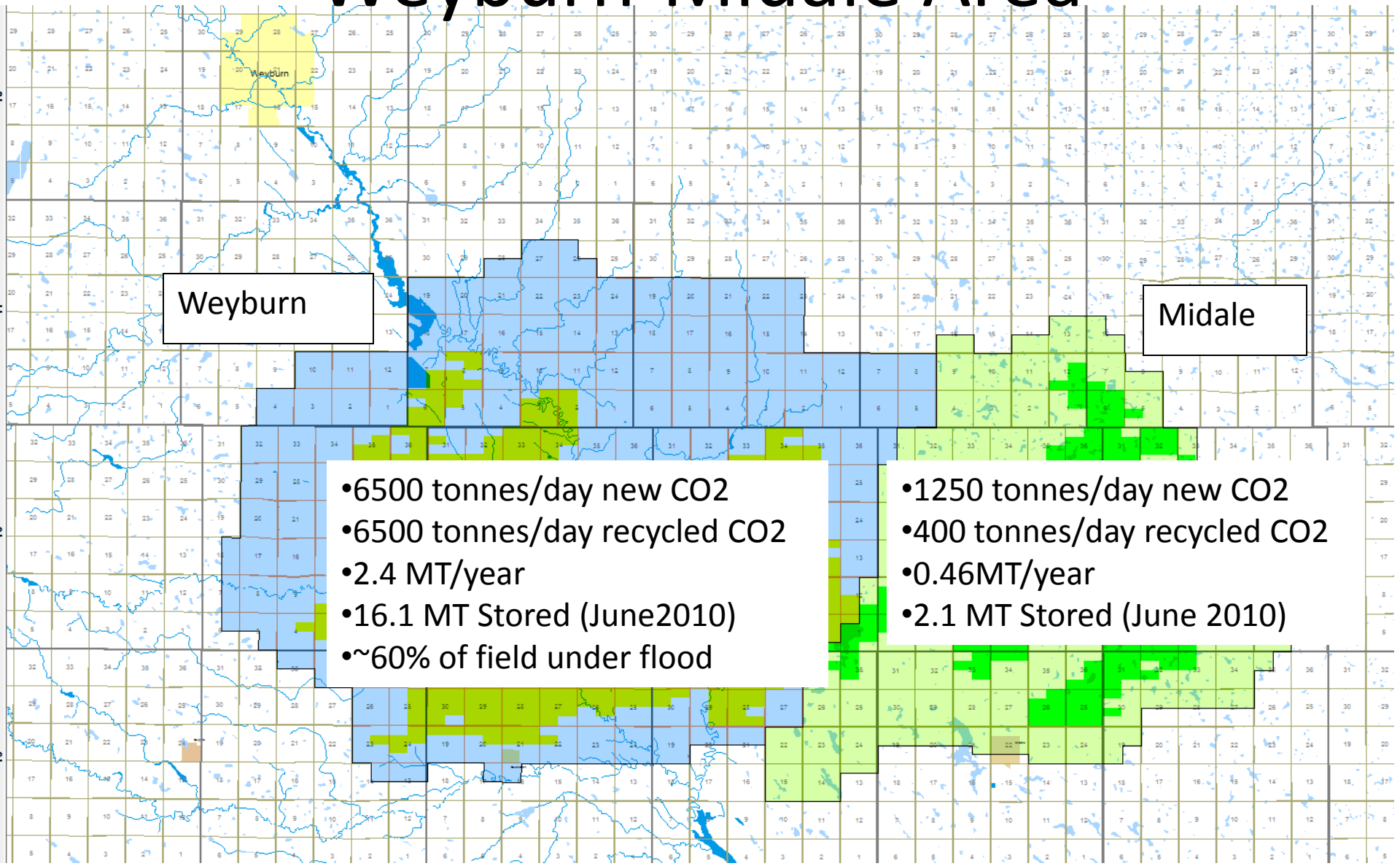
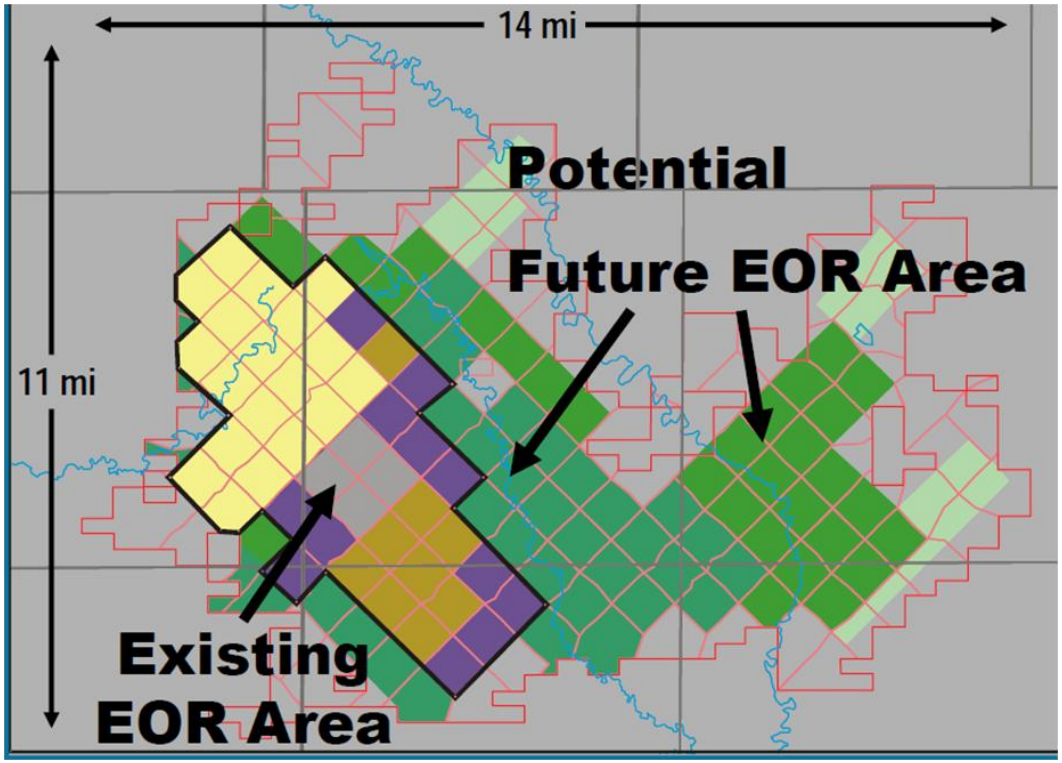
IEA GHG Weyburn-Midale CO2 Storage & Monitoring Project

Regional Carbon Sequestration Partnerships Annual Review
October 5th, 2010
Steve Whittaker, PTRC

Weyburn-Midale Area



Storage Site Operations

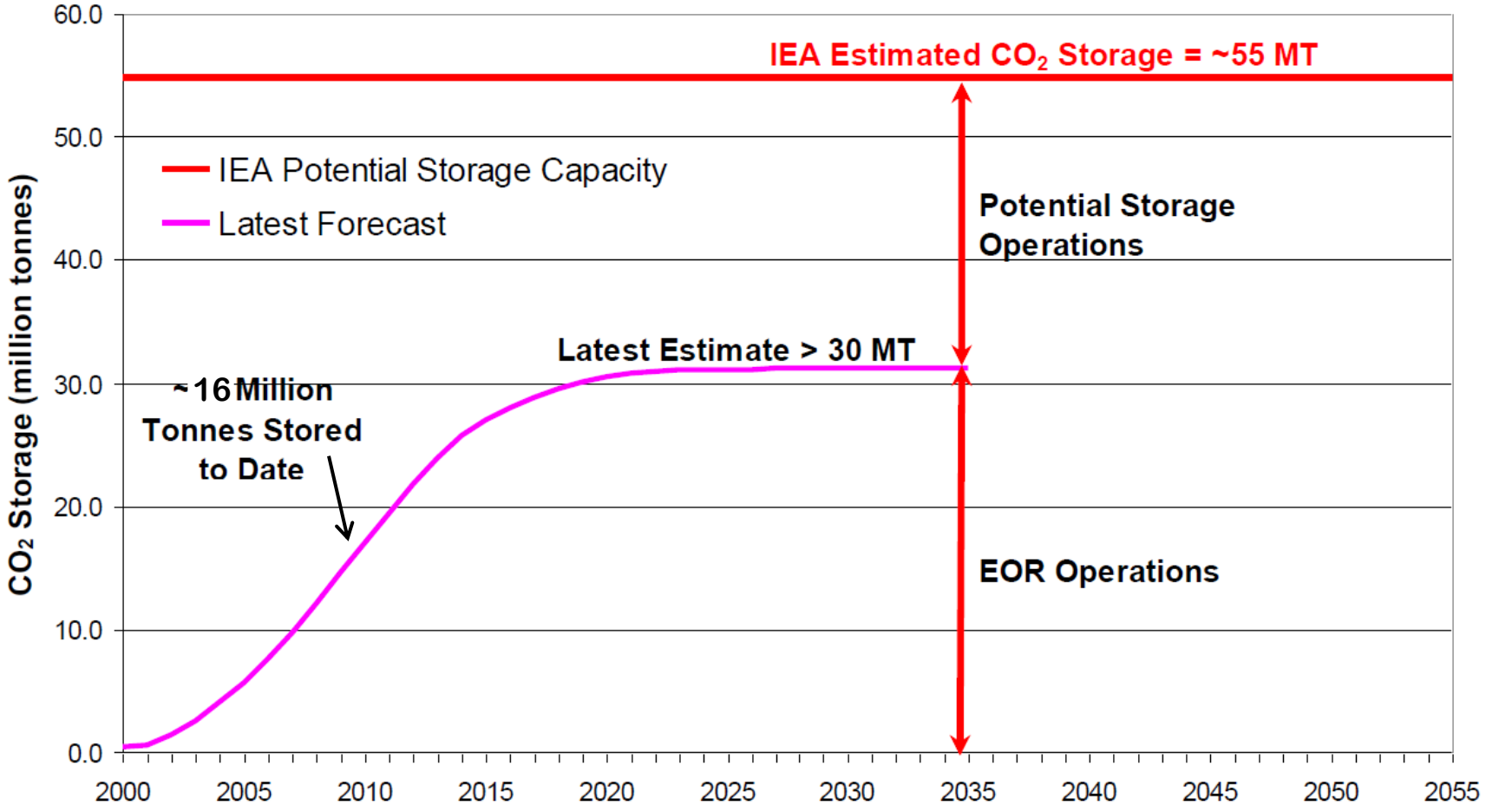


- Weyburn Unit 55,000 acres (85mi^2)
- 1.4 Billion bbls OOIP
  - Sour crude 25-43 API
  - 160 million bbls incremental
  - 30 years of life
- 300 injector wells
  - 160 water only
  - 110 WAG
  - 17 CO_2 only
- 700 producers
- ~50% wells are Hz and 50% vertical

CO_2 Source: Great Plains Synfuel Plant

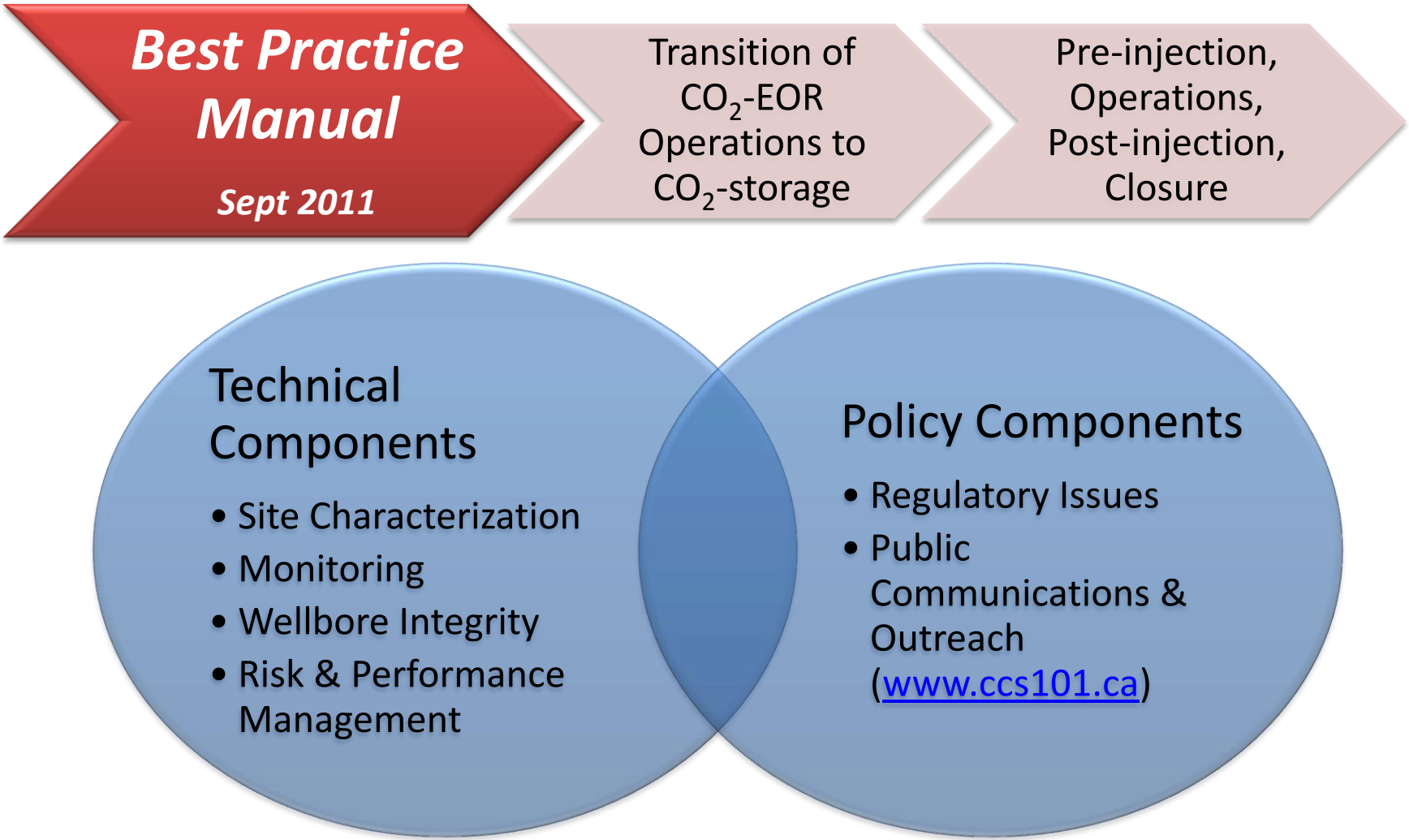
- 250 mmscfd CO_2 by-product of coal (lignite) gasification
  - *approx. 8000 tonnes/day suitable for EOR*
- CO_2 purity 95% (less than 2% H_2S)
- 180 mi pipeline (14 in & 12 in) built & operated by Great Plains

Weyburn CO_2 Storage Capacity



Weyburn & Midale will store CO_2 equivalent to removing about 9 million cars off the road for a year

Project Objectives



Lessons Learned

- Research Coordination
- Site Characterization
- Monitoring
- Public Outreach
- Risk Assessment
- Modeling

IEA GHG WMP Background
Industry-Research Collaboration

IEA WMP Phase 1

IEA Weyburn-Midale Phase 2

Cenovus's Weyburn EOR / CCS Project

pilot studies in 1980's

Apache's Midale EOR / CCS Project

2000 2002 2004 2006 2008 2010

IEA GHG
WEYBURN-MIDALE
CO_2 MONITORING
AND STORAGE PROJECT

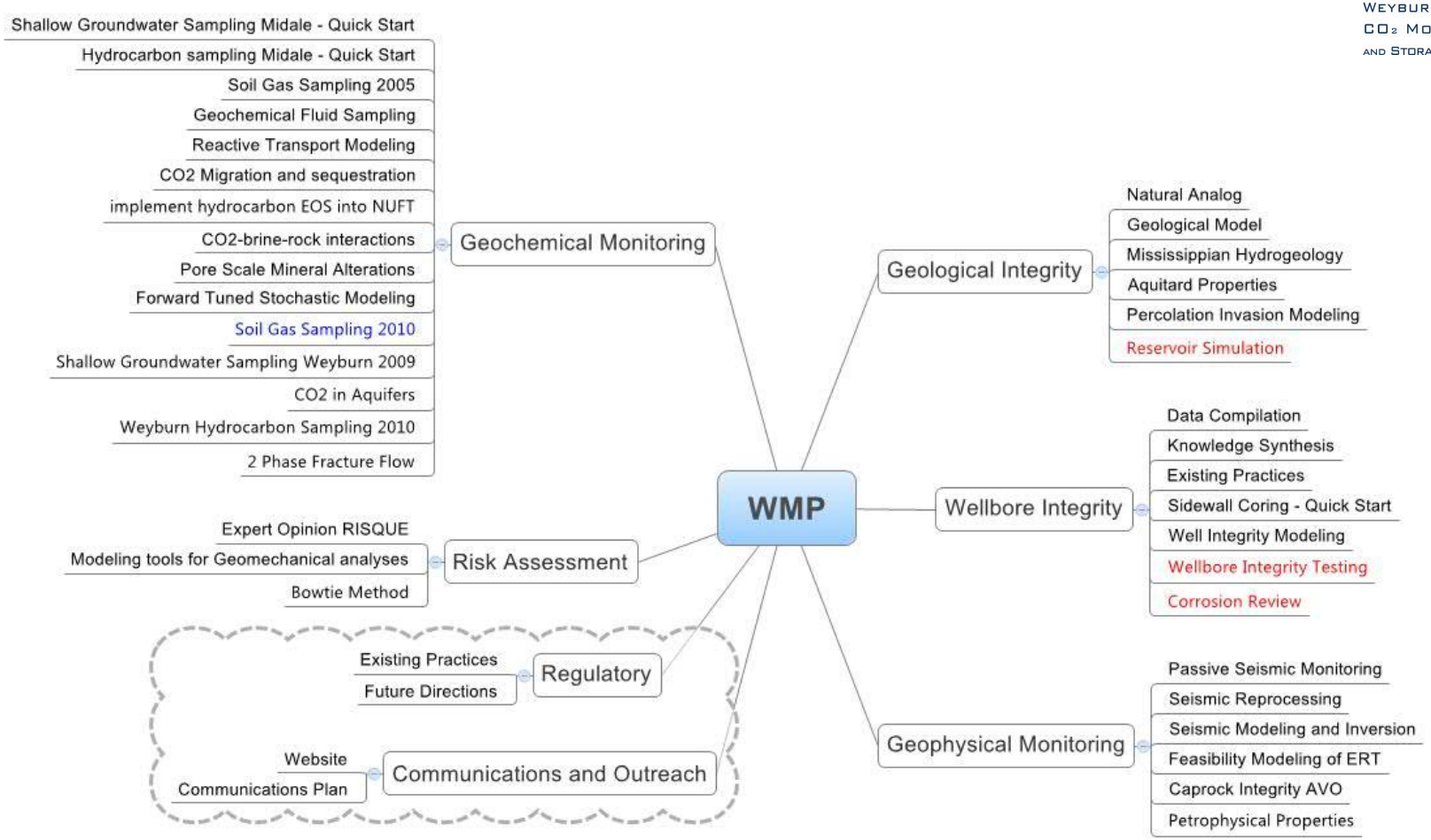
Challenges

- IP
- Confidentiality of Research & Data
  - Industry
  - University
- Technical Integration
- Industrial Site

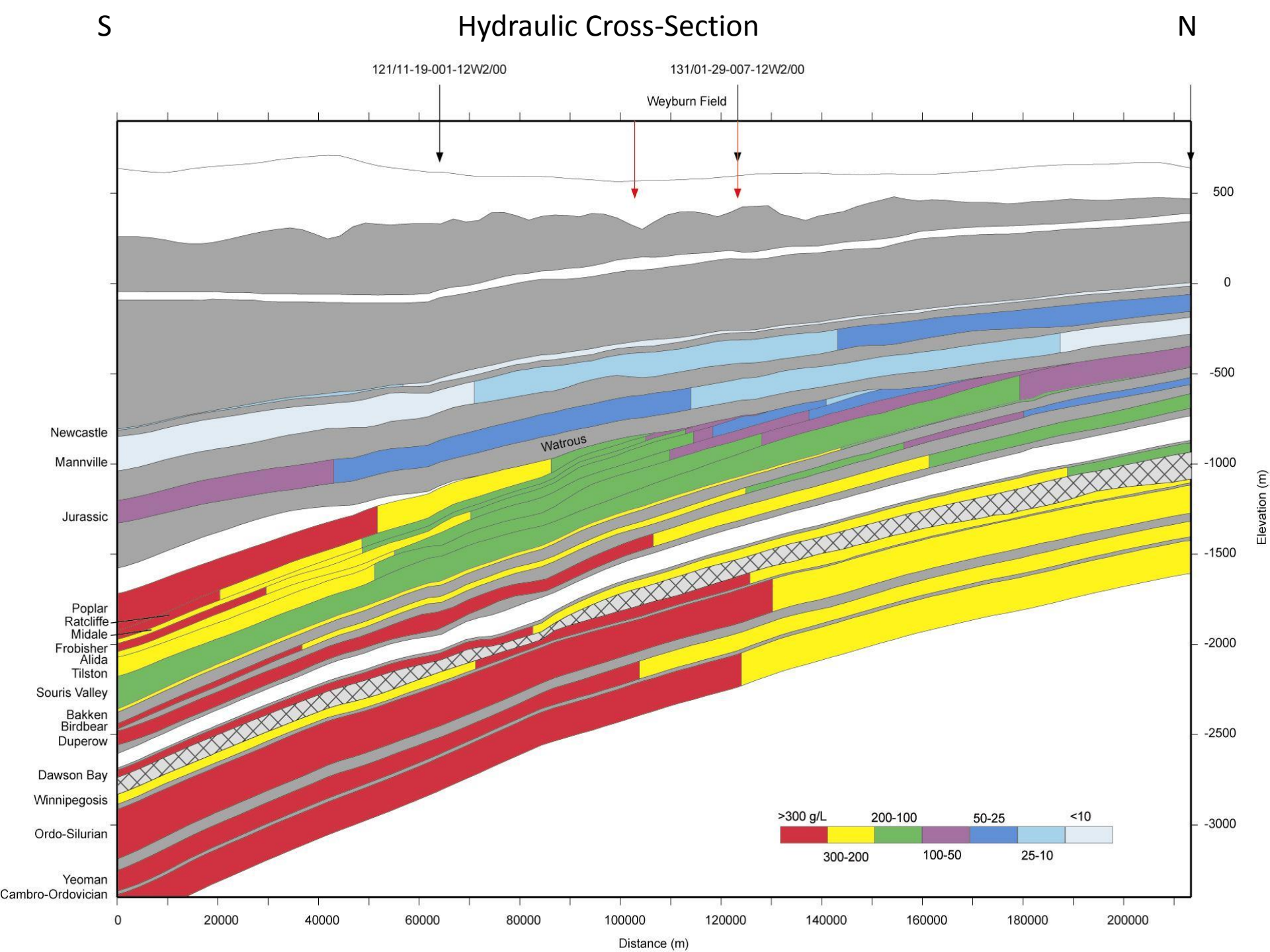
ptrc
Petroleum Technology Research Centre

Research Coordination

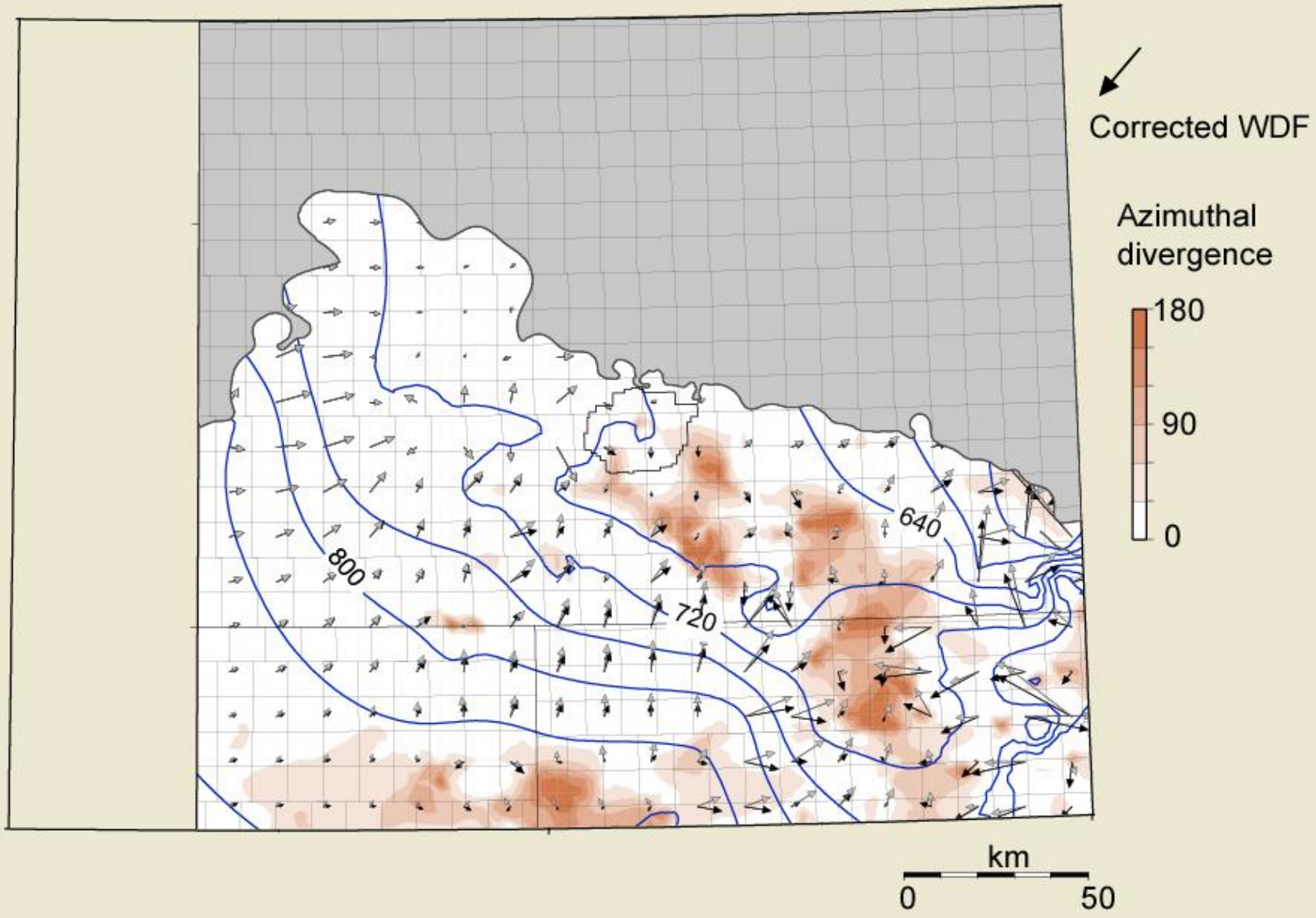
IEA GHG
Weyburn-Midale
CO_2 Monitoring
and Storage Project



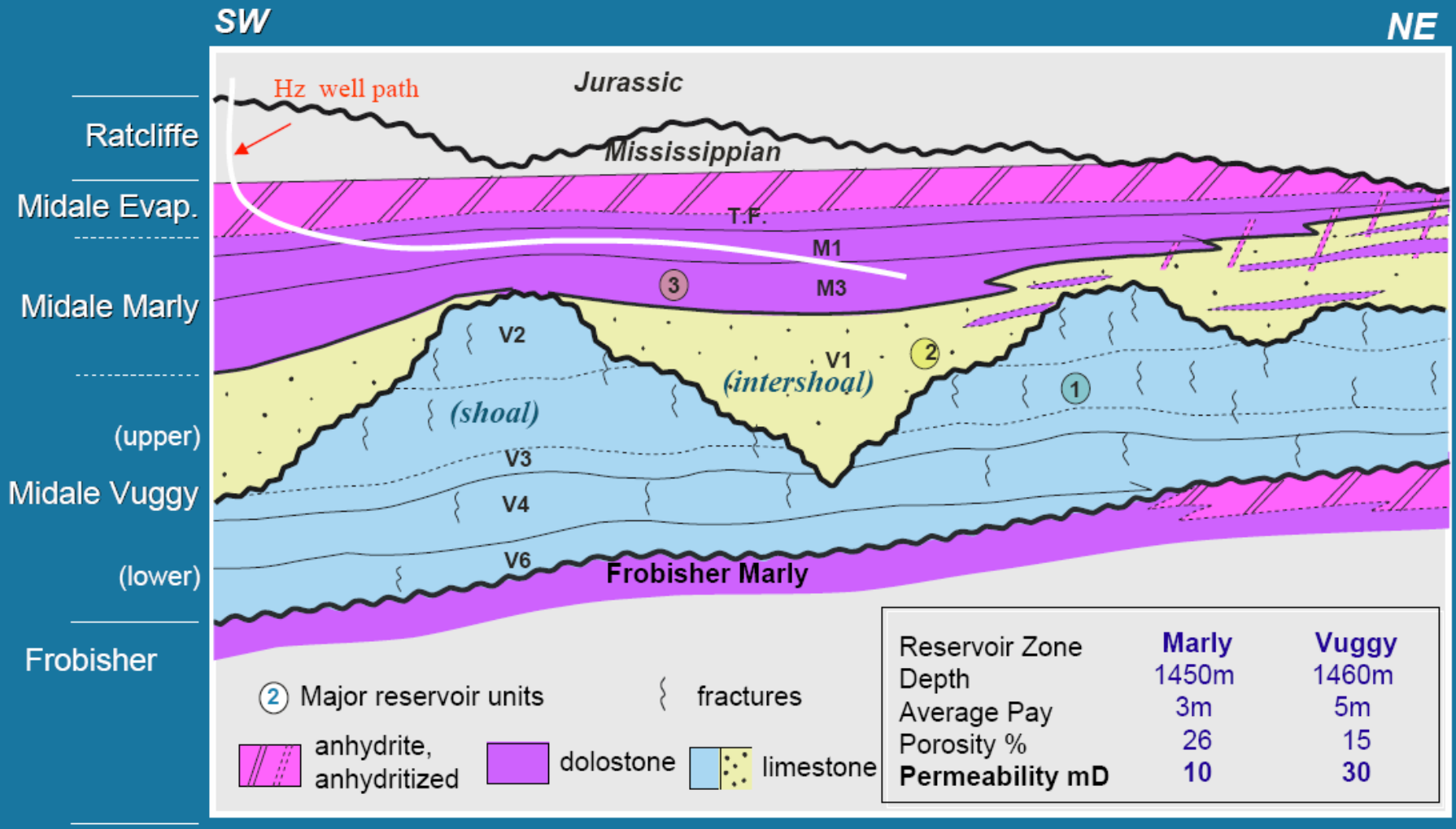
SITE CHARACTERIZATION


S
Hydraulic Cross-Section
N
121/11-19-001-12W2/00
131/01-29-007-12W2/00
Weyburn Field
Watrous
Newcastle
Mannville
Jurassic
Poplar
Ratcliffe
Midale
Frobisher
Alida
Tilston
Souris Valley
Bakken
Birdbear
Duperow
Dawson Bay
Winnipegosis
Ordo-Silurian
Yeoman
Cambro-Ordovician
>300 g/L
300-200
200-100
100-50
50-25
25-10
<10
500
0
-500
-1000
-1500
-2000
-2500
-3000
Elevation (m)
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000
Distance (m)

Typical Mississippian Aquifer: Midale (target aquifer)



Reservoir


SW
NE
Ratcliffe
Midale Evap.
Midale Marly
(upper)
Midale Vuggy
(lower)
Frobisher
Hz well path
Jurassic
Mississippian
T.F.
M1
M3
3
V2
V1
2
1
(intershoal)
(shoal)
V3
V4
V6
Frobisher Marly
2 Major reservoir units
fractures
anhydrite, anhydritized
dolostone
limestone
Reservoir Zone
Depth
Average Pay
Porosity %
Permeability mD
Marly
1450m
3m
26
10
Vuggy
1460m
5m
15
30

Geophysical Monitoring Program

Reprocessing

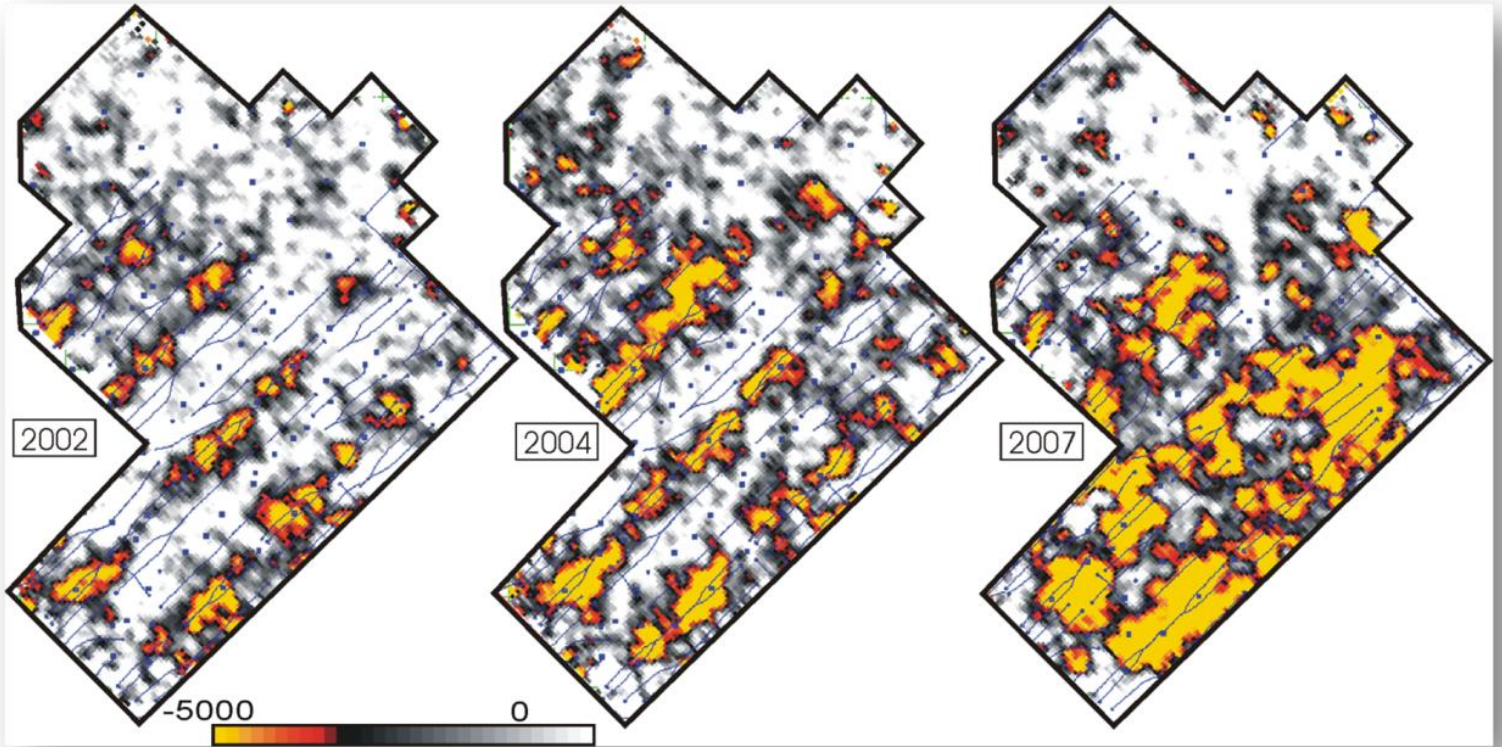
Discriminate pressure vs saturation

Modelling & Inversion

Improve mapping of saturation/pore pressure changes

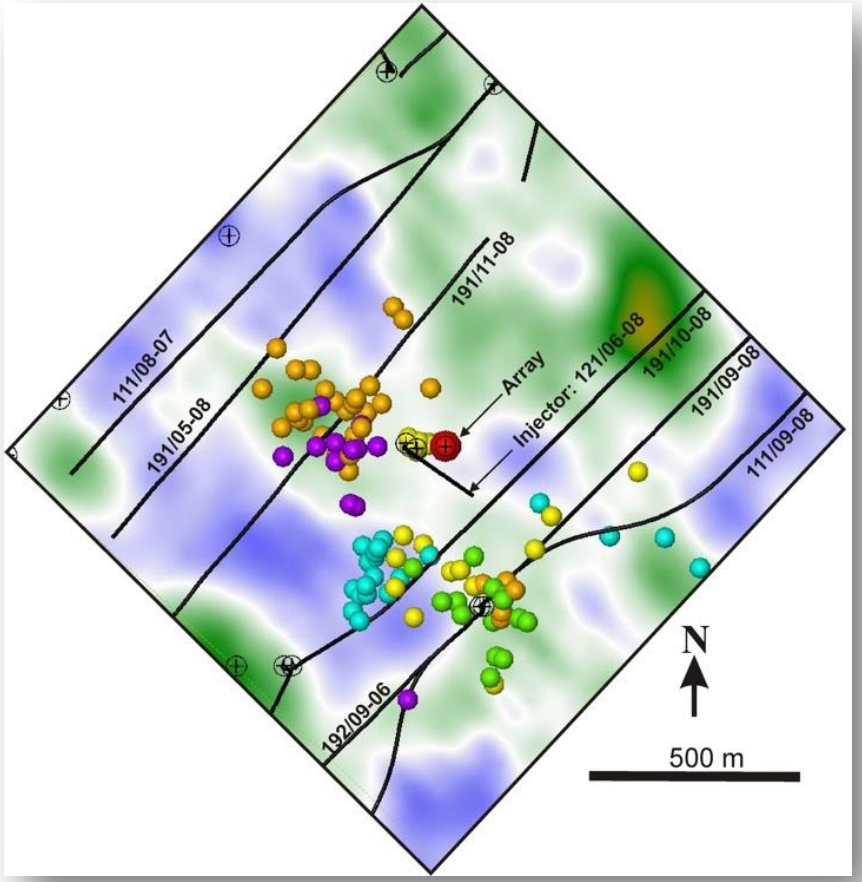
Obtain detailed Rock Properties Data

Weyburn Specific Rock Physics model



Geophysical Monitoring Program

- Passive Seismic Monitoring
  - ongoing since 2003
- Caprock Integrity AVO
- LEERT Feasibility
- Forward tuned stochastic modeling
  - integrate geochemical monitoring and seismic monitoring

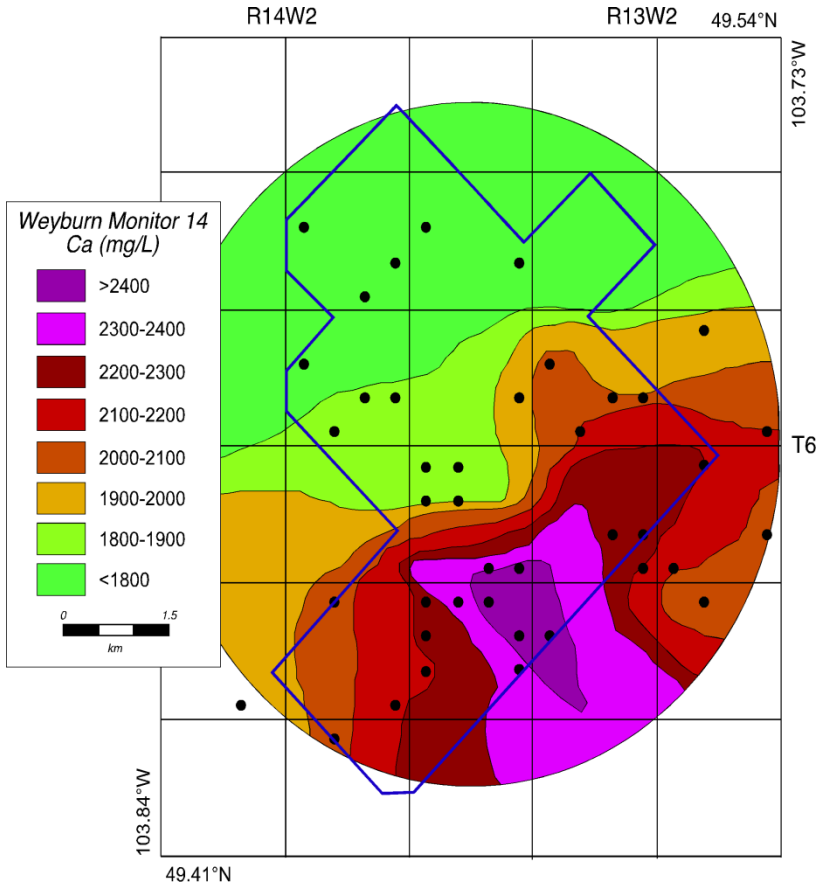


Geochemical Monitoring Program

Fluid Geochemistry monitoring

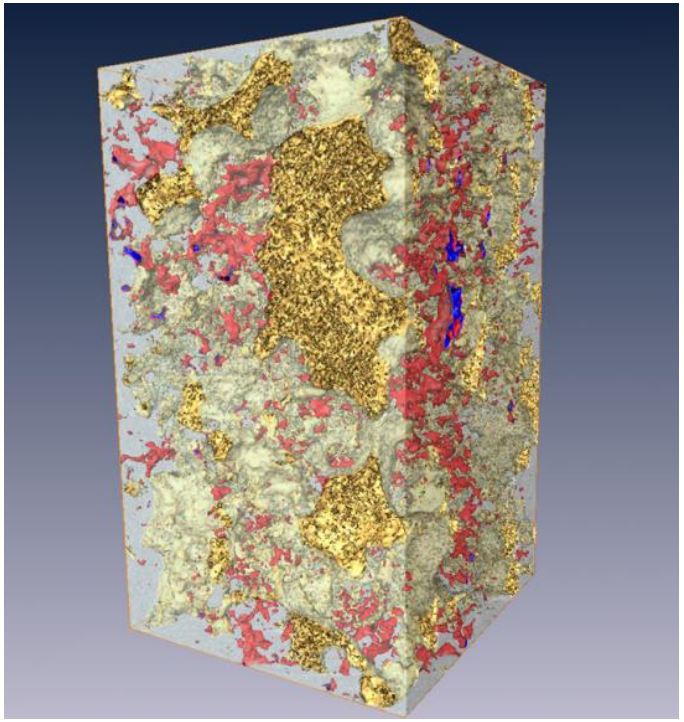
- 16+ sampling trips; 40 to 60 wells; >40 parameters; >30,000 data

Integration of Geochemical monitoring & Reservoir history matching



Geochemical Monitoring Program

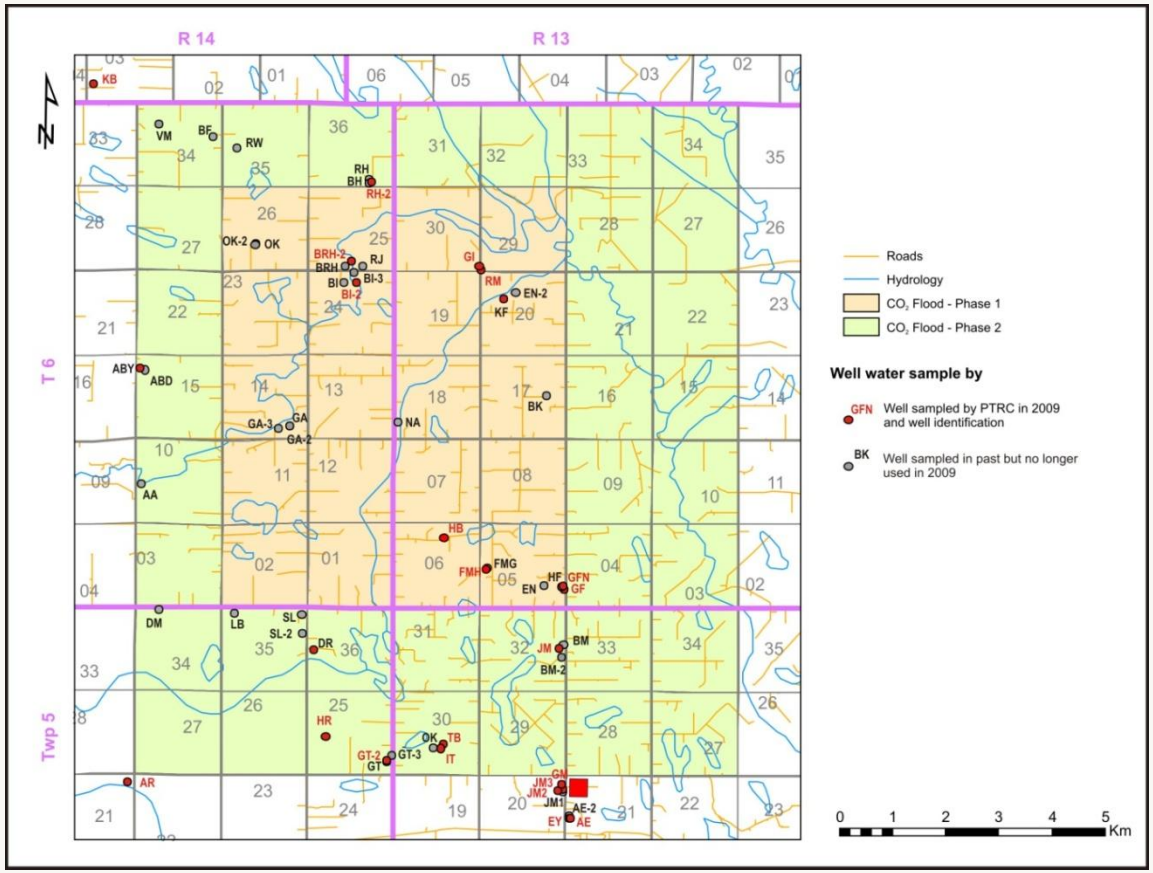
- Reactive Transport modeling (with hydrocarbon EOS)
- Experimental & modeling of CO_2 -brine-rock interaction
- Pore scale mineral alteration
- 2-phase fracture flow
- Soil gas monitoring



Groundwater Well Locations

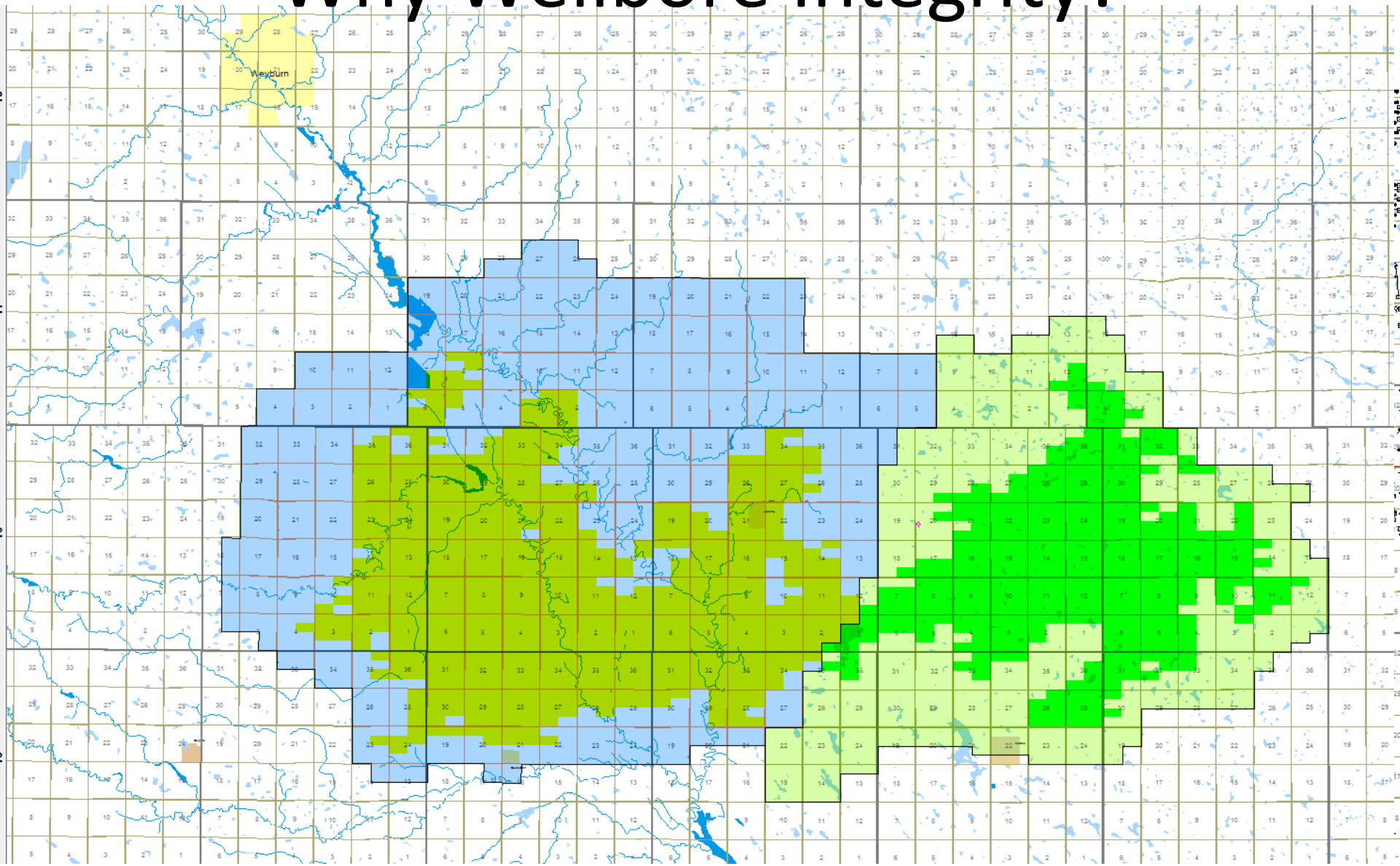
Shallow groundwater monitoring

Eleven monitoring surveys

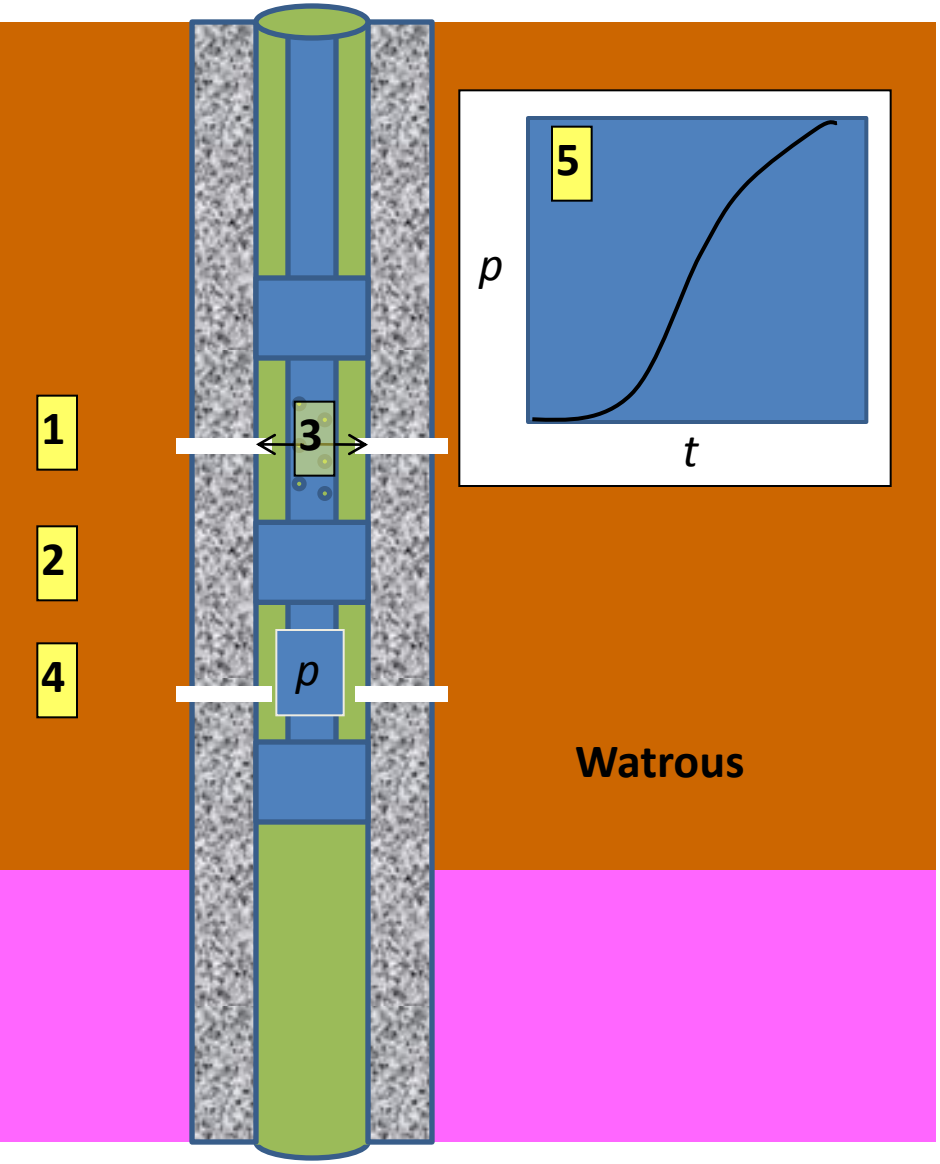


Monitoring Surveys
May/July – 2000
October/December – 2000
June – 2001
October – 2001
October – 2002
June 2006
October/November – 2002
May – 2003
June -2005
June 2006
July/August 2009

Why Wellbore Integrity?

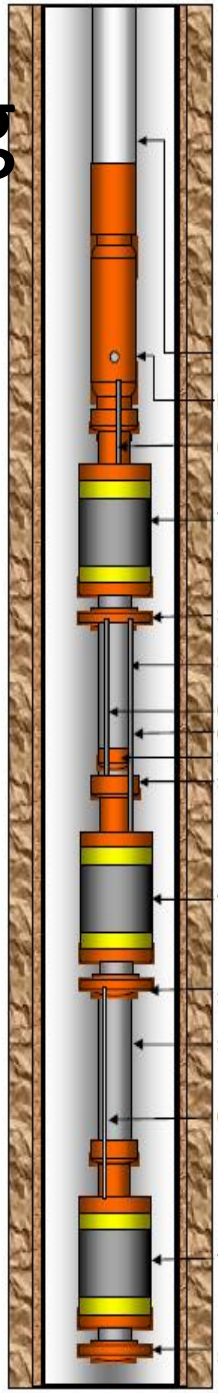


In-Field Pressure Transient Testing



1. Create two slots.
2. Insert tool and inflate all 3 packers.
3. Inject fluid above middle packer.
4. Monitor pressure response below middle packer.
5. Interpret system perm. from pressure-time data.

Preliminary design of testing tool (Opsens Solutions and Tam International)



Assets Valued by Weyburn Stakeholders

- Surface water bodies
- Groundwater
- Native prairie habitats
- Outdoor air quality
- Camping areas
- Wildlife
- Agricultural land
- Varied economic base
- Children's ability to play safely

Affiliation
ED, Big Brothers Big Sisters Association
Mayor of Weyburn
Deputy Fire Chief, Weyburn
Southeast Education Foundation
Mayor of Midale
Weyburn Oil Show Board
Southeast Regional College
Fire Chief / Emergency Planning Coordinator, Weyburn
Weyburn Oil Show Board
Sunrise Community Futures Development Co.
Sask. Min. of Energy & Resources
City Manager, Weyburn
Reeve, Rural Muni. Of Weyburn
Reeve, Rural Muni. Of Cymri
Prairie Farm Rehabilitation Admin.
Prairie Farm Rehabilitation Admin.

Key Stakeholder Questions / Concerns

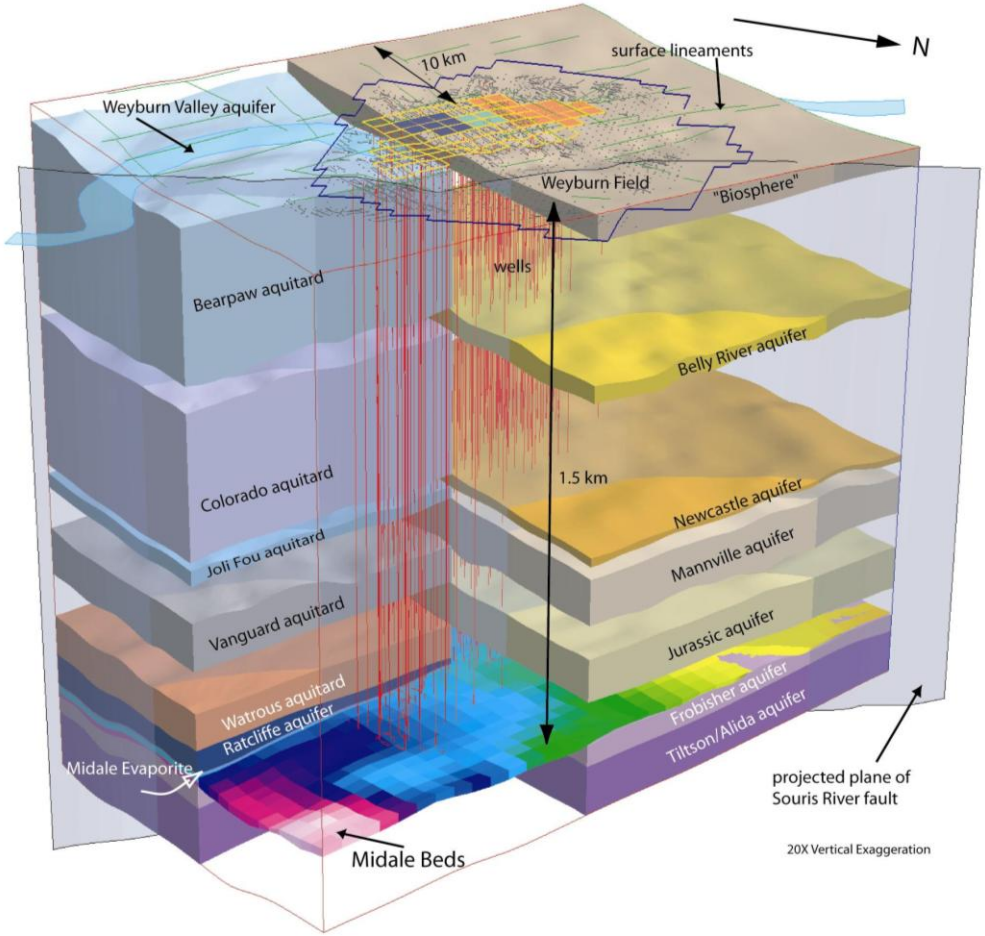
- Fate of CO_2 following injection
  - Where will it go?
  - Can it escape?
  - How will it be monitored?
  - If it migrates, can it be contained?
- Will it cause or be affected by earthquakes?
- Liability
- Regulation
- Effect on reputation of the area

Key Stakeholder Questions / Concerns Cont'

- Impacts:
  - Environment
  - Tourism / business
  - Homes & sub-surface infrastructure
  - Health
  - Aesthetics
- How will the community be engaged?

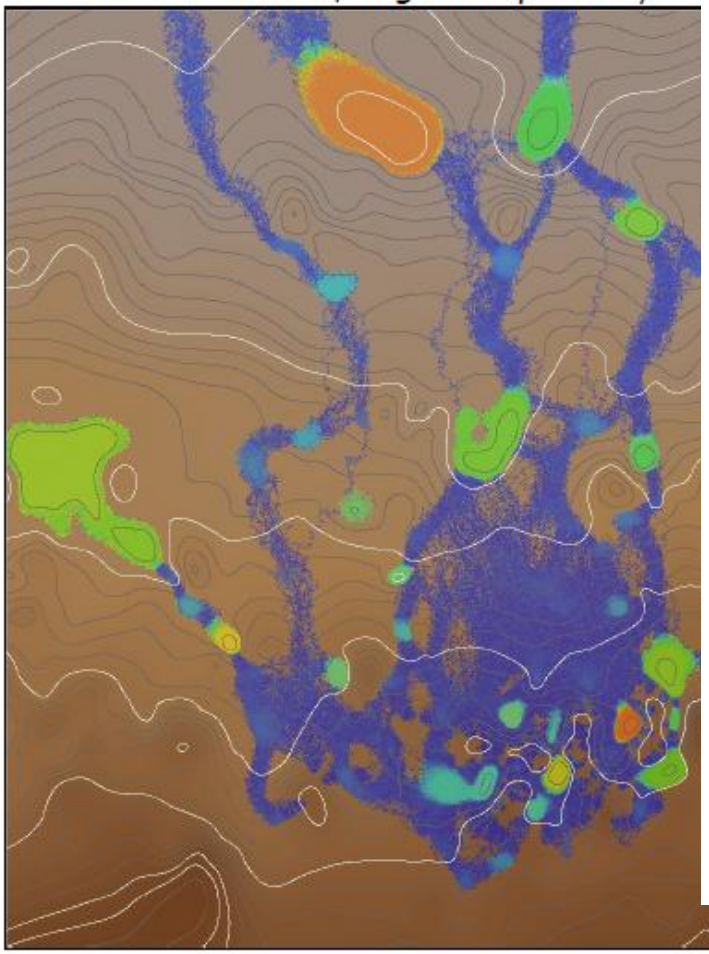
Risk Assessment

- Probabilistic
- Deterministic
- Bowtie
- RISQUE method using Expert Judgement
  - Project needs to demonstrate:
  - It can reduce greenhouse emissions
  - People will be safe
  - It will have an acceptably low impact on the environment

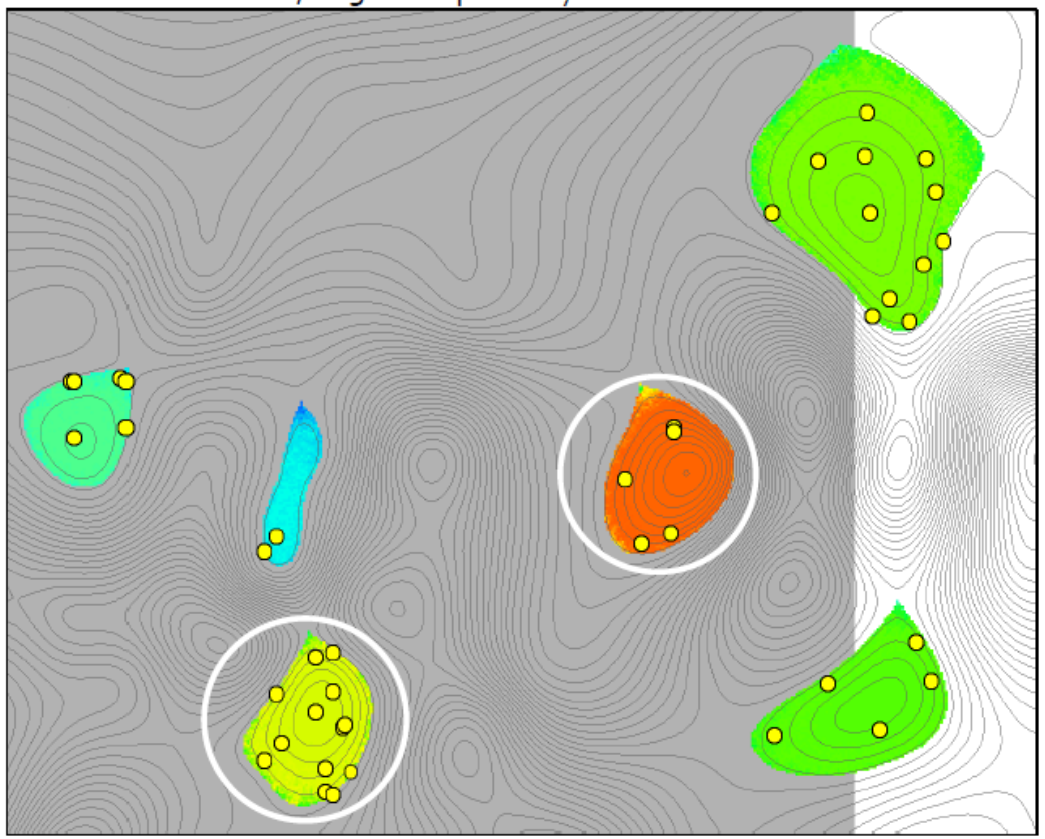


Percolation Modeling

Jurassic Formations, migration pathways



Jurassic Formations, migration pathways



Depth	*1150 meters*	*Brine density*	*1020 kg/m³*	*Porosity*	*0.17*
Temp	*55°C*	*CO2 density*	*480 kg/m³*	*Saturation*	*0.61*
Pressure	*11.7 MPa*	*Brine-CO2*	*38 mN/m*	*Salinity, ppm*	*40,000*

Why is Weyburn Important?

- Anthropogenic source of CO2
- ~ 3MT per year Weyburn and Midale – currently 18MT CO_2 stored
- 10 years of continuous injection history and associated monitoring data
- Baseline & monitoring surveys
  - Seismic, soil gas, shallow groundwater, soil gas

Field Accessibility

- wellbores
- Availability of historical and new data
- 300 tours since injection commenced

ptrc
Petroleum Technology Research Centre

Final Phase Partners

Industry Sponsors

- Apache
- EnCana
- Chevron
- OMV Austria
- Saudi Aramco
- SaskPower
- Schlumberger
- Shell
- DGC
- Nexen

Government Sponsors

- NRCan
- US DOE-NETL
- IEA GHG R&D Programme
- Alberta Energy Research Institute
- Saskatchewan Ministry Energy & Resources
- RITE (Research Institute of Innovative Technology for the Earth – Japan)

Research Organizations

- Alberta Research Council
- Canadian Light Source
- ECOmatters
- Geological Survey of Canada
- Permedia Group
- Saskatchewan Research Council
- TL Watson & Associates
- U of Regina
- U of Saskatchewan
- U of Alberta
- U of Calgary
- Carleton U
- U of Bristol (UK)
- URS Canada Inc.
- Saskatchewan Geological Survey
- Fugro Seismic Imaging
- LLNL
- Bluewave Resources
- Schlumberger-Doll Research
- U of California Irvine